DRAFT
GROUNDWATER INFORMATION SHEET

Perchlorate

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The purpose of this groundwater information sheet is to provide general information regarding a specific constituent of concern (COC). The following information is pulled from a variety of sources and data relates mainly to drinking water. For additional information, the reader is encouraged to consult the references cited at the end of the information sheet.

GENERAL INFORMATION	
Constituent of Concern	Perchlorate
Aliases	Dissociated anion of perchlorate salts, including ammonium, potassium, or sodium perchlorate
Chemical Formula	ClO_4^-
CAS No.	Perchlorates: ammonium 7790-98-9, potassium 7778-74-7, sodium 7601-89-0
Storet No.	A-031
Summary	The California Department of Health Services (DHS) is required to adopt an MCL for perchlorate by January 2004. Until then, DHS uses an advisory action level of 4 µg/L. Common anthropogenic sources of perchlorate include perchlorate salts used in industrial and military applications. Perchlorate is highly soluble in water, highly mobile, and once released, is persistent in groundwater. Based on DHS data through 2002, 251 public drinking water wells (of approximately 4000 sampled) have had detections of perchlorate, with most detections occurring in Los Angeles, San Bernardino and Riverside Counties.

REGULATORY AND WATER QUALITY LEVELS[1]		
Type	**Agency**	**Concentration**
Federal MCL	US EPA, Region 9	N/A
State MCL	DHS	Expected Jan. 2004
Action Level	DHS	4 µg/L
Detection Limit for Purposes of Reporting (DLR)	DHS	N/A
Others: Preliminary Remediation Goal – Tap Water Public Health Goal (PHG)	 US EPA, Region 9 OEHHA	 18 µg/L Draft 6 µg/L (Final due Jan. 2003)

[1]These levels generally relate to drinking water, other water quality levels may exist. For further information, see A Compilation of Water Quality Goals (Marshack, 2000).

SUMMARY OF DETECTIONS IN PUBLIC DRINKING WATER WELLS[2]	
Detection Type	**Number of Groundwater Sources**
Number of public drinking water wells[3] with detections.	251 of 4006 sampled.
Top 3 counties having public drinking water wells[3] with perchlorate detections.	Los Angeles, San Bernardino, Riverside

[2]Based on DHS data collected from 1997-2000 (Geotracker). See Figures 1 and 2.
[3]In general, drinking water from active and standby wells is treated or blended so consumers are not exposed to water exceeding MCLs. Individual wells and wells for small water systems not regulated by DHS are not included in these figures.

ANALYTICAL INFORMATION	
Analytical Test Methods	US EPA Method 314
Detection Limit	1 µg/L
Known Limitations to Analytical Methods	Ion chromatography (IC) is the state-of-the-art technology for perchlorate analysis. Historical methods based on gravimetry, spectrophotometry, or atomic absorption are non-specific for perchlorate. There are several existing IC methods, including US EPA Method 314.0, Dionex, and one developed by the Air Force Research Laboratory/Operational Toxicology Branch (AFRL/HEST). These methods depend upon retention time in a standard to identify any peak with the same or similar retention time as perchlorate in a water sample. The robustness

	of the existing IC methods for perchlorate in water analysis with high total dissolved solids is questionable. Research is underway that will evaluate the variability, reproducibility, accuracy and precision of the IC methods across laboratories and to determine the appropriate concentration ranges for measurement.
Public Drinking Water Testing Requirements	In January 2001, DHS identified perchlorate as an unregulated chemical requiring monitoring (Title 22, California Code of Regulations §64450). It is "unregulated" by DHS because it has no drinking water standard or MCL. As a result of the DHS monitoring requirement, public water systems began collecting information on the presence of perchlorate in their drinking water supplies. These data are needed to enable DHS to ascertain the extent to which perchlorate is present in drinking water supplies, and to determine treatment costs, in case a drinking water MCL specific for perchlorate is determined to be appropriate. As of Oct 2002, 4932 drinking water sources in California have been sampled for perchlorate with 284 detections (DHS website, Sept. 2002)

PERCHLORATE OCCURRENCE	
Anthropogenic Sources	Perchlorate originates as a contaminant in the environment from the release of solid salts of ammonium, potassium, or sodium perchlorate. The majority of locations where perchlorate has been detected in the groundwater are associated with the manufacturing or testing of solid rocket fuels for the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA), and with the manufacture of ammonium perchlorate. Perchlorate salts are also used in: fireworks; automotive air bag inflators; nuclear reactors; electronic tubes; lubricating oil; the tanning and finishing of leather; the mordant of fabric and dyes; electroplating; aluminum refining; rubber manufacture; the production of paints and enamels. Perchlorate is also reported to have been present in certain types of fertilizers. Potassium perchlorate has been used therapeutically to treat hyperthyroidism resulting from an autoimmune condition known as Graves' disease. Diagnosis of thyroid hormone production uses potassium perchlorate in some clinical settings. In addition, perchlorate may be detected at hazardous waste

	sites.
Natural Sources	Perchlorate is reported to be present in some caliche formations in Chile that are used to produce nitrate fertilizers.
History of Occurrence	Several hundred drinking water wells were sampled by DHS for perchlorate beginning February 1997. Perchlorate was first detected in drinking water wells (up to 260 µg/L) near the Aerojet site in Sacramento County. Groundwater treated to remove volatile organic chemicals (such as trichloroethylene) was re-injected into the groundwater. Perchlorate, also in the contaminated shallow groundwater, has been present in the reinjected water at concentrations up to 8,000 µg/L. Perchlorate was also detected (up to 159 µg/L) in drinking water wells in Los Angeles County. Several sites have been identified as potential sources of contamination, including Aerojet (Azusa), Whittaker-Bermite (Santa Clarita), and Jet Propulsion Laboratory (Pasadena). DHS also found perchlorate in drinking water wells in Riverside (up to 29 µg/L) and San Bernardino County drinking water wells (up to 325 µg/L) and in 24 agricultural wells (up to 221 µg/L). The perchlorate contamination is associated with a TCE plume at the former operation site of the Lockheed Propulsion Company. Perchlorate was detected at 270 µg/L in an inactive well near former fireworks manufacturing site near Rialto. Other locations of groundwater contamination by perchlorate: • an explosives manufacturing facility near Lincoln, at 1,200 and 67,000 µg/L. • United Technologies in Santa Clara, up to 180,000 µg/L. • Whittaker Ordnance Facility (near Hollister in San Benito County), up to 88 µg/L; an agricultural well in the vicinity at 34 µg/L, and a private well, 810 µg/L.
Contaminant Transport Characteristics	Perchlorate is highly soluble and mobile in groundwater. It is stable at low concentrations and is an inert ion. There is the potential for its precipitation in the subsurface; however, reduction/sorption occurs to a lesser extent. The persistence of perchlorate in groundwater results primarily from a combination of aerobic conditions and a lack of a sufficient electron donor for biodegradation.

REMEDIATION & TREATMENT TECHNOLOGIES

Since 1997, much progress has been made in perchlorate treatment technologies. Conventional filtration, sedimentation or air stripping technologies cannot remove perchlorate. Effective treatment technologies include:

- **Biological –** Microbes are used to break down the perchlorate ion into oxygen and chloride. This technology has been successful in reducing concentrations in water from 75 ppb to less than detectable levels at the San Gabriel Valley Superfund sites. It is also being used at the Aerojet site in Sacramento.
- **Ion Exchange –** Ion exchange processes have been used in homes and offices for decades in water softeners. A more elaborate form of this technology has been successful in reducing concentrations in water from 75 ppb to less than detectable levels at the San Gabriel Valley Superfund sites. This process concentrates the perchlorate into brine, which must be disposed of.
- **Reverse Osmosis and Nanofiltration** - are both effective in removing perchlorate, but can be costly. These methods are still experimental.
- **Liquid Granulated Activated Carbon (GAC)** is effective for a very limited time before carbon replacement is required. This method is currently used at several sites in Southern California (Redlands, San Gabriel Valley) supplemented with air-stripping and UV/Oxidation

HEALTH EFFECT INFORMATION

In the body, perchlorate interferes with the uptake of iodine by the thyroid gland, causing disruption of thyroid hormone production. Thyroid hormones help to regulate the body's metabolism and physical growth. Inhibited thyroid function can result in hypothyroidism and, in rare cases, thyroid tumors. Pregnant women and their developing fetuses may suffer the most serious health effects from perchlorate contamination in drinking water, particularly in the first and second trimesters of pregnancy. During this period, the fetal thyroid is not yet fully functional, so the mother's thyroid must be able to produce enough extra hormone to enable her baby's brain to develop properly. Because pregnancy already places a strain on the maternal endocrine system, pregnant mothers and their fetuses are particularly susceptible to perchlorate's inhibition of iodine intake. Women with critically low levels of iodine can miscarry, or their developing fetuses can suffer congenital hypothyroidism, which may stunt the fetus's physical growth and impede proper development of its central nervous system. Even moderate to mild iodine deficiency during pregnancy has been linked to impaired brain development and lower IQs for children born under these conditions (OEHHA, 2002).

Following the initial detections in 1997, DHS informed drinking water utilities that US EPA had evaluated the health effects of perchlorate as part its Superfund activities (US EPA, 1992, 1995). US EPA used studies on humans as most appropriate for evaluating the health risks of perchlorate to establish a "provisional" reference dose (RfD). Data were derived from medical patients given perchlorate to treat hyperactive thyroid glands (Graves' disease). The release of iodine from the thyroid and inhibition of iodine uptake by the thyroid were the most sensitive indicators of perchlorate effects. For these effects, the US EPA (1992) identified a no observed adverse effect level (NOAEL) of 0.14 mg/kg/day and a 1000-fold uncertainty factor (UF). Later, US EPA reviewed its earlier report and material submitted by the Perchlorate Study Group, and maintained the earlier 1000-fold UF, but also included a 300-fold UF (US EPA, 1995).

The US EPA evaluations corresponded to a range of 4 to 18 µg/L in drinking water. DHS, in cooperation with OEHHA, reviewed the US EPA perchlorate evaluations, and established an action level of 18 µg/L. DHS recently reduced its action level from 18 µg/L to 4 µg/L, equal to the analytical quantitation limit. Perchlorate concentrations at or below 4 µg/L are not considered by DHS and OEHHA to pose a health concern for the public, including children and pregnant women and their developing young.

In January 2002, US EPA released an external peer review draft toxicity assessment, entitled Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization. The report includes a draft reference dose of 0.00003 mg/kg/day. Using standard toxicological assumptions, this value would result in a protective level in drinking water of less than 1 µg/L.

Also in 2002, OEHHA released a draft PHG of 6 µg/L for perchlorate. The Final PHG is due in January 2003. DHS will use the PHG in proposing a perchlorate MCL (expected in January 2004).

KEY REFERENCES

1 California Department of Health Services. *Perchlorate in California Drinking Water: Status of Regulations and Monitoring Results.* http://www.dhs.cahwnet.gov/org/ps/ddwem/chemicals/perchl/perchlindex.htm (Oct. 23, 2002)
2 California Environmental Protection Agency. Office of Environmental Health Hazard Assessment. March 2002. Draft Public Health Goal for Perchlorate in Drinking Water. http://www.oehha.ca.gov/water/phg/pdf/PHGperchlorate372002.pdf
3 California Environmental Protection Agency / Regional Water Quality Control Board, Central Valley Region. August 2000. *A Compilation of Water Quality Goals*. Prepared by Jon B. Marshack. http://www.swrcb.ca.gov/rwqcb5/available_documents/wq_goals/wq_goals.pdf
4 U.S. Environmental Protection Agency. Groundwater and Drinking Water. *Drinking Water Contaminant List: Perchlorate*. http://www.epa.gov/ogwdw/ccl/perchlor/perchlo.html (Oct. 23, 2002)

FOR MORE INFORMATION, CONTACT:
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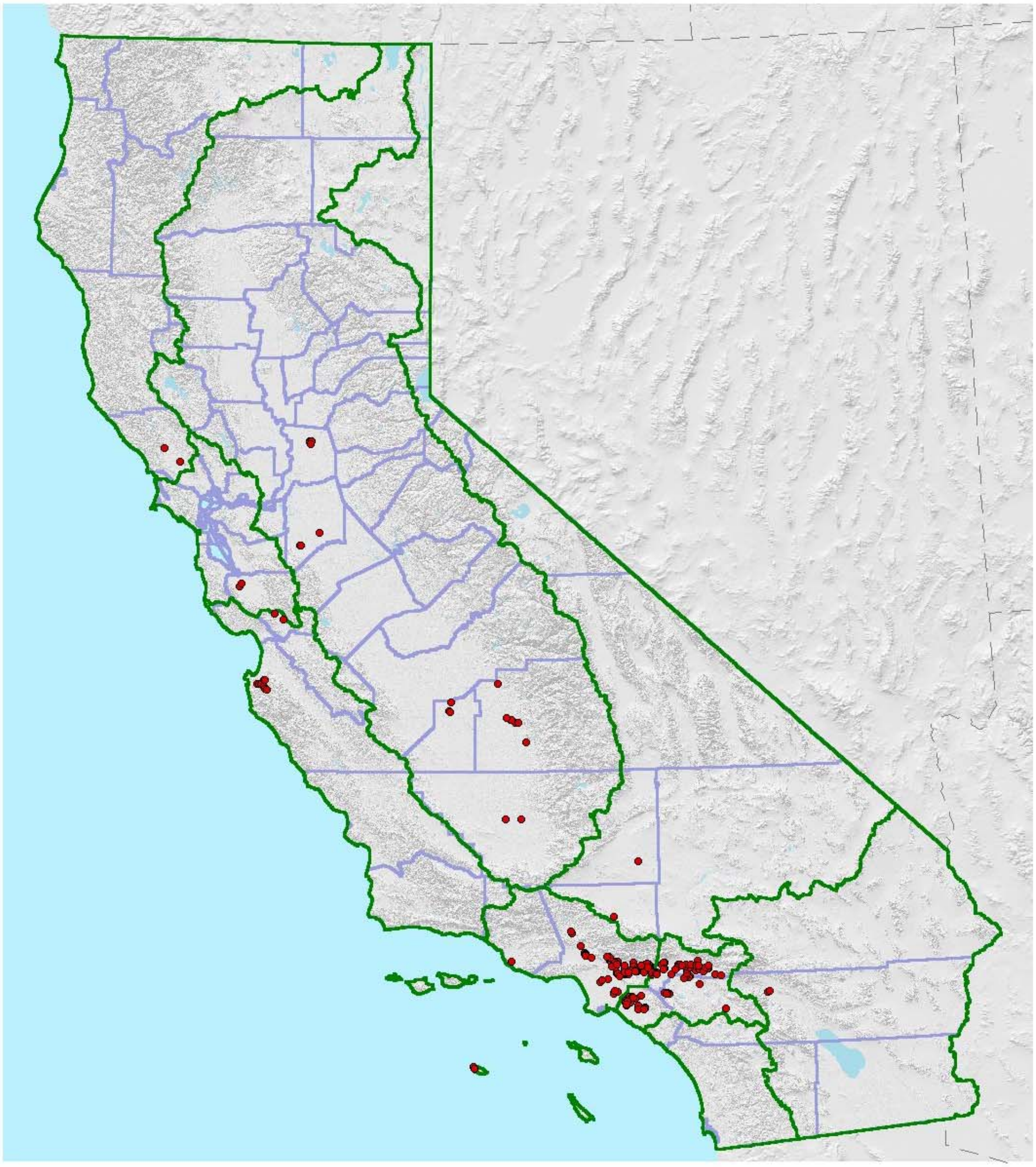
Groundwater Information Sheet: Perchlorate
Figure 1



Active and Standby DHS Wells (251 Total*) with at Least One Detection of Perchlorate >= 4 PPB Action Level

Source: 1984 - 2000 DHS Data (Map Revised 09/26/02)
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Groundwater Information Sheet: Perchlorate
Figure 2

Abandoned, Destroyed, and Inactive DHS Wells (57 Total*) with at Least One Detection of Perchlorate >= 4 PPB Action Level

Source: 1984 - 2000 DHS Data (Map Revised 09/26/02)
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